

# **Commercialization of Technologies to Lower Defense Costs**

## **Final Demonstration/Validation Report For STAPP Bullet Catcher Evaluation at Fort A.P. Hill**

**March 2, 2006**

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## **ACRYNYMS AND ABBREVIATIONS**

|            |  |
|------------|--|
| <i>CTC</i> | Concurrent Technologies Corporation                  |
| DCC-W      | Defense Contracting Command-Washington               |
| DoD        | Department Of Defense                                |
| NDCEE      | National Defense Center For Environmental Excellence |
| P2         | Pollution Prevention                                 |
| Pb         | Lead   |
| RCRA       | Resource Conversation Recovery Act                   |
| TCLP       | Toxicity Characteristic Leaching Procedure           |

## EXECUTIVE SUMMARY

This effort was completed under the National Defense Center for Environmental Excellence (NDCEE) Task N.319. Under the Defense Contracting Command-Washington (DCC-W) directive for this task, Concurrent Technologies Corporation (*CTC*) proceeded directly into the development of a Phase 2 Dem/Val Plan in order to facilitate this initiative. As part of its effort to continue Pollution Prevention (P2), and reduce the impacts of training on the environment, the Department of Defense (DoD) is being proactive by testing an alternative backstop for use on military small arms firing ranges.

Due to information listed in this report, one could assume that all on-target bullets fired upon the Bullet Catcher installed at Fort A.P. Hill's Range 4 were stopped and contained within the bullet trap itself and that no bullets/lead or lead contaminated water were introduced to the environment. Sifting efforts, hot spots only, showed that 67 pounds of bullets and the associated lead were contained within the Bullet Catcher that would have been introduced directly to the environment if using a conventional soil berm.

On the contrary the same assumption can not be made regarding the Bullet Catcher installed at Fort A.P. Hill's Range 5, because of the documented damage to the bottom rubber liner. Although the depth of the granular rubber was not sufficient to properly decelerate .50 caliber rounds, which allowed those rounds to penetrate through the bottom rubber liner, the top rubber cover performed properly. The vendor originally stated that the Bullet Catcher technology would properly accommodate rounds up to and including 12mm. The .50 caliber round is slightly larger at 12.7mm. The vendor has since stated that with further research the depth of the granular rubber could be changed accordingly to properly accommodate .50 caliber rounds.

When compared to the use of a conventional soil berm, the use of a Bullet Catcher on Range 4 could drastically decrease the amount of lead introduced into the environment. Soil erosion and lead migration would also be reduced or possibly be eliminated.

Due to bullets penetrating the bottom rubber liner of the Range 5 Bullet Catcher, an accurate comparison to a conventional soil berm cannot be conducted. If the proper depth of granular rubber to adequately decelerate .50 caliber rounds could be determined, the same Bullet Catcher could also decrease or eliminate the amount of lead introduced to the environment on Range 5. In addition, throughout the demonstration it has become obvious that many rounds did not hit the backstop area and would not be caught by either a berm or a Bullet Catcher.

From the data collected during this demonstration/validation, it can be assumed that a Bullet Catcher installed upon a clean berm (or a lead contaminated but exempt from regulations berm) would have a cost savings in the event of a range closure requiring full remediation. When installed upon a clean, lead-free range, the amount of lead introduced to the environment would be minimal, if any, assuming all rounds are on target and impact the Bullet Catcher. In the instance when a Bullet Catcher is installed upon a lead-contaminated berm, the amount of lead introduced to the environment would be limited to the amount of lead present at the time of installation (Again, assuming that all rounds are on target and impact the Bullet Catcher.).



## **1.0 INTRODUCTION**

The following sections will briefly provide information concerning the objectives of the demonstration/validation testing as well as the approach. For more information please review the *Demonstration/Validation Plan for STAPP Bullet Catcher at Fort A.P. Hill* in **Appendix A**.

### **1.1 Goals and Objectives**

The objective of this Phase 2 project is to demonstrate and validate the STAPP Bullet Catcher at an active small arms range (Ft. A.P. Hill) as an operational and viable environmentally sound alternative to conventional soil berms/backstops. The Phase 3 Dem/Val task will seek to achieve the following goals:

- Perform a cost benefit analysis.
- Verify if the Bullet Catcher produces results that meet and/or exceed conventional soil berms/backstops.
- Decrease the threat of lead contamination to the environment by verifying water containment and lead containment aspects of the Bullet Catcher.
- Demonstrate the containment characteristics of the runoff/leachate collection system and any interim leachate disposal requirements.
- Verify/eliminate health and safety hazards.
- Verify the ease and frequency of maintenance/repairs, plus actual maintenance costs (including, equipment and labor).
- Demonstrate the performance of the Bullet Catcher using various small arms rounds including 5.56mm, 7.52mm, 9mm, (and .50 caliber, if feasible).
- If possible verify that the Bullet Catcher will not become a fire hazard, especially when subjected to tracer rounds. Or, at what threshold can tracer rounds be successfully accommodated without concern of igniting any of the system's materials.
- Demonstrate the disassembly characteristics:
  - Demobilization and preparation logistics,
  - Ease of disassembly,
  - Speed of disassembly,
  - Level of skill for disassembly,
  - Site reconstruction requirements, if any,
  - Materials disposal requirements (as a hazardous waste)
  - Regulatory processes and standards,
  - Ultimate disposal logistics and associated costs.

### **1.2 Approach**

In order to properly evaluate the effects of different caliber/size rounds on the Bullet Catcher(s) in a realistic training scenario, each range must be evaluated based on normal operations. The designated person(s) for data gathering and

maintenance was on-site at each range to collect data and to also ask personnel using the range to fire upon the Bullet Catcher. By doing so, the Bullet Catcher performance was evaluated in a realistic training scenario.

## **2.0 INITIAL BERM CONDITIONS**

Two Bullet Catchers were installed at Fort A.P. Hill to incorporate a wider variety of ammunition types and sizes. STAPP and Fort A.P. Hill decided that Range 4 and Range 5 were the best candidate ranges for this demonstration.

### **2.1 Range 4 Berm**

The initial physical condition of the Range 4 berm is best depicted in Figures 1 and 2. Large craters, created from years of firing, are clearly visible. The craters were formed as a result of bullets penetrating the soil and eroding the berm. The craters in the near vicinity of the Bullet Catcher are approximately 80 inches long x 52.5 inches wide x 12 inches deep. There is woody vegetation present for the prevention of soil erosion.



**Figure 1. Original Condition of Range 4 Close-up.**



**Figure 2. Original Condition of Range 4.**

## **2.2 Range 5 Berm**

The physical condition of the Range 5 berm is best depicted in the Figure 3. Range 5 does not have any craters similar to the ones seen on Range 4 and has little, if any, woody vegetation or plant life. Erosion of the soil has created deep ruts on the face of the berm. There is also a large distance (271 feet, 6 inches) between the firing point and the berm, which allows bullets to “travel” upwards and beyond the height of the berm. By the observing the surrounding tree line and plant growth, it is obvious that bullets pass over the berm, cutting down trees and plant-life. This is shown clearly in Figure 3.



**Figure 3. Original Condition of Range 5.**

### **3.0 EQUIPMENT AND INSTALLATION**

#### **3.1 Equipment**

All equipment, supplies, and tools required for the Bullet Catcher installations were supplied by the vendor. The Bullet Catcher equipment and supplies were delivered in a standard forty-foot sea container and offloaded via fork-truck. The figures below show the delivery and materials of construction for the Bullet Catchers.



**Figure 4. Off-loading Bullet Catcher Equipment.**



**Figure 5. Off-loading Granular Rubber.**



**Figure 6. Bullet Catcher Materials.**



**Figure 7. Bullet Catcher Stake Covers, Water Collection Materials, and Stakes.**

Tools required for the construction of the Bullet Catchers involved basic hand and power tools (sledge hammer, hammer, tape measure, handsaw, level, shovel, rake, pick, utility knife, battery-powered circular saw, battery-powered drill/screw driver) and an excavator machine with rough terrain tires equipped with a fork and bucket attachment, as shown below in Figure 8.





**Figure 8. Excavator with Rough Terrain Tires, Fork, and Bucket Attachment.**

### **3.2 Installation**

On 16 December 2004, approval was received from Fort A.P. Hill that installation of the Bullet Catchers may begin. Personnel from STAPP and BAHR Training Group were on-site and began to prepare the Range 5 berm for installation of Bullet Catcher immediately upon receiving Fort A.P. Hill approval. The berm needed little preparation.

The Range 4 berm required considerably more preparation than the Range 5 berm. The excavator was used to scrape back the woody vegetation and to grade the berm to the desired slope of thirty-one degrees. The craters were filled using certified-fill, supplied by BAHR Training Group. The entire ground was then covered with the certified-fill and graded to the desired slope as shown in Figure 9 and 10.



**Figures 9 and 10. Preparing Range 4 Berm.**



**Figure 11. Range 4 Craters Filled and Graded to 31 Degrees.**

Once the ground was prepared, the area was measured and stakes were driven into the soil at designated locations, as shown in Figure 12 and 13. These stakes provide support for the entire Bullet Catcher.



**Figures 12 and 13. Driving in Support Stakes on Range 4.**

The plank-based frame was then constructed. Planks were cut to size, using a battery-powered circular saw and a handsaw, and secured in place using a battery-powered drill/screw-gun (See Figures 14 and 15).



**Figure 14. Inspecting Support Stakes Upon Range 4.**



**Figure 15. Laying the Range 4 Bullet Catcher Frame.**

The bottom rubber liner was laid in place following the completion of the frame. This liner was pieced together with all seams tested per STAPP specifications to ensure water/air-tightness prior to delivery to Fort A.P. Hill. There are straps on the upper portion of the liner that are secured to the top of the Bullet Catcher frame. These straps prevent the liner from shifting. Installation of the bottom rubber liner was simple and required approximately five to ten minutes to complete. Figures 16 and 17 refer to the installation of the bottom rubber liner.





**Figure 16. Laying the Bottom Rubber Liner.**



**Figure 17. Bottom Rubber Liner in Place.**

The water collection reservoir was then placed on top of the bottom rubber liner in the lowest section of the Bullet Catcher (See Figures 18 and 19). Please see Figures 18 and 19 for more detail. This system consists of a perforated polyethylene tube and end cap.



**Figure 18. Water Collection Reservoir Installed.**



**Figure 19. View Port of Water Collection Reservoir.**

The next step of the installation was to add the granular rubber. The granular rubber was shipped from Sweden in one-ton super-sacs, which allowed the material to compact itself. Due to the compaction of the granular rubber, it was not feasible to empty the sacs directly into the Bullet Catcher. Instead, the sacs were emptied into a roll-off box, Figure 20, and the compressed chunks were broken apart using shovels, picks, and rakes. Once the granular rubber was no longer compacted, the excavator bucket attachment was used to scoop the material out of the roll-off box, Figure 21, to place it into the Bullet Catcher.



**Figure 20. Emptying Super-Sacs of Granular Rubber.**



**Figure 21. Scooping Loosened Granular Rubber from Roll-off Container.**

The granular rubber was added until a total depth of twenty-four inches was achieved (See Figures 22 and 23). After the desired depth was achieved, the granular rubber was smoothed and graded to a thirty-one degree slope (See Figure 24).



**Figures 22 and 23. Adding Granular Rubber into the Bullet Catcher Frame.**



**Figure 24. Addition of Granular Rubber Complete.**

After the slope and thickness of the granular rubber met the vendor's specifications, the top rubber cover was applied. Figures 25 and 26 depict the application of the top rubber cover. The top rubber cover was cut to size prior to shipment to Fort A.P. Hill. Each roll was approximately four feet wide. One roll at a time was taken to the top of the Bullet Catcher and rolled down over the granular rubber. It was essential to create an overlap of four to six inches as each roll was laid to ensure a proper seal.





**Figures 25 and 26. Application of Top Rubber Cover.**

Once the top rubber cover was properly in place, the seams were glued to create a water/air-tight seal (See Figures 27 and 28). This process involved lightly scuffing the overlap area with sand paper, removing all dirt/moisture by wiping the area clean with rubbing alcohol, and applying a STAPP-supplied acrylate-based glue. Light hand-pressure was applied until the glue set properly.



**Figure 27. Sealing the Seams of the Top Rubber Cover.**



**Figure 28. Seams of Top Rubber Cover Sealed.**

The side planks that hold the top rubber cover to the Bullet Catcher frame were then secured using a battery-powered drill and STAPP-supplied screws. The final step was to trim the top rubber cover to remove all excess material. With this complete, so was the installation of the Bullet Catcher. Figures 29, 30, 31, and 32 show the complete Bullet Catcher.



**Figures 29, 30, 31, and 32. Different Angles of the Complete Installation of the Bullet Catcher at Range 4.**

#### **4.0 FIRING DATA**

The test demonstration began on 18 February 2004 and finished on 15 August 2004. During this timeframe information relating to the type and size of rounds fired was collected. This information included the:

- Date,
- Lane number,
- Number of rounds fired,
- Caliber/size of the rounds fired,
- Type of round (armor-piercing and/or tracer),
- Firing position,

- Firing mode,
- Type of firing (fixed or free),
- Number of known misses,
- Start/finish time,
- Temperature during firing,
- Type of weather (wet/dry), and
- The group firing.

#### **4.1 Range 4**

The Bullet Catcher that was installed on Range 4 had 14,357 5.56mm and 2,700 9mm rounds fired upon it during the six month firing period. There were no armor piercing rounds and roughly ten tracer rounds fired upon this Bullet Catcher. The majority of the rounds fired were evenly spread among the three firing lanes with 5,742 rounds fired on lane 52, 5,632 on lane 53, and 5,683 on lane 54. There was no downtime associated with this Bullet Catcher that prevented troops from training on Range 4. Therefore the Bullet Catcher did not negatively impact any training activities.

**Appendix A** contains the data sheets for all firing that occurred upon the Range 4 Bullet Catcher during the demonstration/validation test period.

#### **4.2 Range 5**

The single lane Bullet Catcher that was installed on Range 5 had 8,277 5.56mm, 2,470 7.62mm, and 5,430 .50 caliber rounds fired upon it during the six month firing period. There were 2,500 .50 caliber armor-piercing rounds and approximately 2,380 tracer rounds of various calibers fired upon this Bullet Catcher. There was no downtime associated with this Bullet Catcher that prevented troops from training on Range 5. All maintenance was conducted at times when the range was not scheduled for use. The Bullet Catcher did not interfere with training activities on either of the ranges.

**Appendix B** contains the data sheets for all firing that occurred upon the Range 5 Bullet catcher during the demonstration/validation test period.

#### **4.3 Lead**

The following amounts of lead (Pb) per round were used as reference for this demonstration:

- 5.56mm---M855, 2.07grams of Pb
- 7.62mm---M80, 6.28 grams of Pb
- 9mm---M882, 6.54 grams of Pb
- .50 caliber---M33, 0.72 grams of Pb



Table 1 lists the total number of each size/caliber of round fired at each Bullet Catcher as well as the amount of total lead for each size round.

**Table 1. Total Rounds and Associated Amount of Lead Fired Upon each Bullet Catcher.**

| <b>RANGE 4</b> | <b>Size/Cal.</b> | <b>Number of Rounds Fired</b> | <b>Amount of Pb /Round</b> | <b>Total Pb</b>                 |
|----------------|------------------|-------------------------------|----------------------------|---------------------------------|
|                | 5.56mm           | 14,357                        | 2.07 grams                 | 29,718.99 grams or 65.52 pounds |
|                |                  |                               |                            |                                 |
|                | 9mm              | 2,700                         | 6.54 grams                 | 17,658 grams or 38.93 pounds    |
|                |                  |                               |                            |                                 |
| <b>RANGE 5</b> |                  |                               |                            |                                 |
|                | 5.56mm           | 8,277                         | 2.07 grams                 | 17,133.39 grams or 37.77 pounds |
|                |                  |                               |                            |                                 |
|                | 7.62mm           | 2,470                         | 6.28 grams                 | 15,511.60 grams or 34.20 pounds |
|                |                  |                               |                            |                                 |
|                | .50 cal          | 5,430                         | 0.72 grams                 | 3,909.60 grams or 8.62 pounds   |

Although there were 16,177 rounds fired upon the Range 5 Bullet Catcher, it is believed that a high percentage of the rounds fired did not actually impact the Bullet Catcher. There is a large distance (271 feet, 6 inches) between the firing point and the berm, which allow bullets to “travel” upwards and beyond the height of the berm, as well as to the sides and below the Bullet Catcher. By observing the surrounding tree line and plant growth, it is probable that bullets pass over the berm, cutting down trees and plant-life. This is not an ideal distance with or without the addition of a Bullet Catcher and is clearly shown in Figure 3.

It is recommended that the design of the range be reconsidered. On Range 5 the distance from the firing sites to the target areas is 10 meters. That leaves approximately 241 feet of open space between the target and the berm. One option would be to move the firing sites and target areas closer to the berm, perhaps leaving an open space between the target and berm of 25 meters or so. This could eliminate the problem of bullets “traveling” beyond, below, and to the sides of the berm.

Another option would be to build up the firing point so that when troops are firing from the prone position they are firing at a lesser upward angle. This would only solve the problem of “overshooting” the berm. Bullets may still “travel” to the sides and below the berm.

## **5.0 MAINTENANCE**

This section describes the maintenance evaluation that was performed during this demonstration. It compares historical maintenance information to the amount of maintenance performed during this test.

Maintenance performed to the Bullet Catchers during the six-month test period was minimal and required nothing more than a few hand tools, patch material, and less than three hours total to complete. There was not any range down time that prevented training efforts during this demonstration/validation firing period.

### **5.1 Berm Maintenance Prior to Bullet Catcher Installation**

According to the Department of Public Works at Fort A.P. Hill, there has historically been little maintenance performed to Range 4 and Range 5 berms themselves. Approximately ten years ago, Range 4 had the vegetation and trees cleared from it, fill added to it, and reseeded. The labor and material costs totaled approximately \$8,000.

Approximately five years ago, Range 5 had the vegetation and trees cleared from it, fill added to it, and reseeded. The labor and material costs totaled \$16,000-\$18,000.

### **5.2 Maintenance #1**

On 1 March 2004, thirteen days after test initiation, the NDCEE received notification from Fort A.P. Hill stating that the top rubber cover of the Range 4 Bullet Catcher had been damaged. Fort A.P. Hill stated that there was a small tear in the top rubber cover that might require repair. The NDCEE, BAHF Training Group, and STAPP received photographs of the damage and a trip to Fort A.P. Hill to verify if repair was or was not necessary was scheduled for 4 March 2004.

The top rubber cover had a small v-shaped tear approximately the size of a US quarter (See Figure 33). There was not a gaping hole, just a tear. It is believed that a tumbling bullet that had hit the target frame prior to the top rubber cover caused the tear. Mr. Mike Hargett of BAHF Training Group determined that no maintenance repairs were necessary at this time.



**Figure 33. Tear in Top Rubber Cover, Approximately the Size of a U.S. Quarter.**

### **5.3 Maintenance #2**

On 27 April 2004, seventy days after test initiation, Fort A.P. Hill reported to the NDCEE that there was damage to the top rubber cover on Range 5 that definitely required maintenance. The damage was caused by the 2,500 armor piercing .50 caliber rounds that were fired upon the Bullet Catcher on 24 April 2004. There was damage to the frame/planking as well as the top rubber cover.

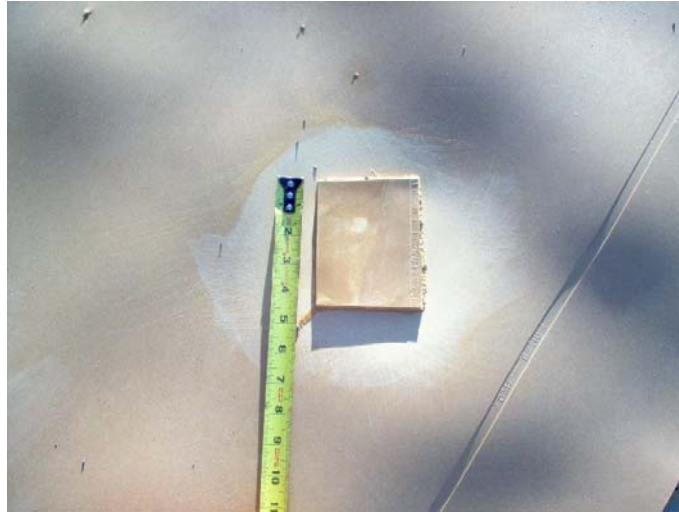
On 29 April 2004 all parties met at Range 5 to observe a small area on the left side of the Bullet Catcher that required patching (See Figure 34).



**Figure 34. Damage on Left Side of Range 5.**

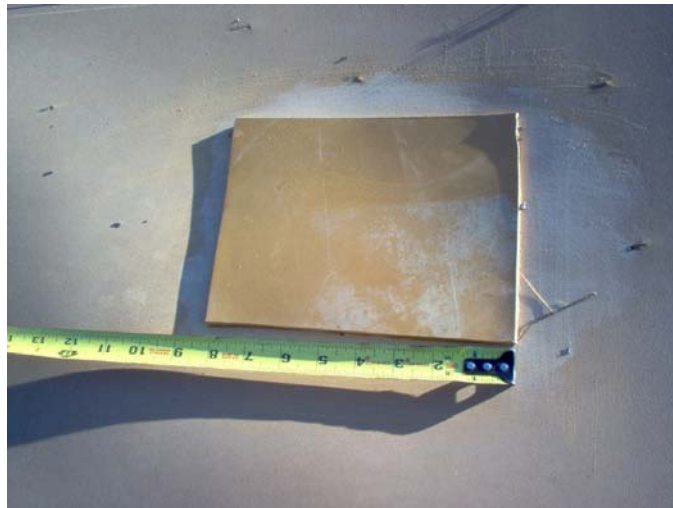
Steps taken to repair the damaged area included sanding the perimeter of the damaged area and wiping it clean using rubbing alcohol. The repair patch

consisted of the very same material as the top rubber cover and was cut slightly larger than the damaged area to allow an approximate 1-2” overlap. The overlap provides a sound surface for the repair patch to adhere to. The under side of the repair patch was also sanded and cleaned with rubbing alcohol. Once the damaged area and patch were sanded and cleaned, a bead of the STAPP supplied glue was placed on both the perimeter of the damaged area as well as the coordinating under side of the patch. The patch was laid on top of the damaged area and hand-pressure was applied. The time required to complete the repair was approximately 5-7 minutes. For repair results see Figure 35.



**Figure 35. Repair Patch to Damage Depicted in Figure 35.**

There was a larger area of the top rubber cover on the right side of the Bullet Catcher that required patching as well. The very same steps taken to repair the smaller area on the left side were followed. The repair took approximately 5-10 minutes to complete. For results see Figure 36.



**Figure 36. Top Rubber Cover Patch on Right Side of Range 5 Bullet Catcher.**

There was also damage along the left side of the Bullet Catcher just inside of the frame/planking, see Figure 37, which required the same repair steps previously mentioned.



**Figure 37. Left Side Damage to Top Rubber Cover and Frame/Planking on Range 5.**

The frame/planking was also damaged and a section needed to be replaced. After a replacement plank was cut to size it was screwed into place. The patch and plank replacement took approximately 25-30 minutes to complete.

There was another smaller area on the left side that required repair. This area was also just inside of the frame/planking. The same repair steps were taken with exception to replacing the planking. Time to repair this area was approximately 10 minutes.

The top of the Bullet Catcher had severe damage to the upper portion of the top rubber cover (See Figures 38, 39, and 40).



**Figures 38, 39, and 40. Damage to the Upper Portion of the Top Rubber Cover of the Range 5 Bullet Catcher.**



The bullets hit the top portion of the Bullet Catcher because of the long distance between the firing point and the Bullet Catcher (approximately 271'). This large distance allows bullets to "travel" to the edges of the Bullet Catcher and beyond. Bullets that impact the Bullet Catcher at or near the edges are not able to penetrate the Bullet Catcher properly and therefore cannot be appropriately retained. The top portion of the Bullet Catcher, where it becomes flat, showed the most damage. Bullets that were fired at an upward angle or from the prone position caused this damage. When the bullets finally reach the Bullet Catcher they have traveled roughly 271' and have had the opportunity to "climb". The bullet then lightly penetrates the flattened out portion of the Bullet Catcher and simply skims the top rubber cover, tearing it as it passes. This damage is not due to a malfunction or inadequacy of the Bullet Catcher to perform, but is a direct result of the range design. Perhaps if the Bullet Catcher had been designed and constructed several feet taller this damage would not be an issue.

The top portion of the Bullet Catcher was patched. Steps taken to repair the damaged area were the same as for the smaller patches. Two large repair patches were needed for this top portion. Approximately 25-30 minutes were required to repair the entire top portion of the Bullet Catcher.

There was also a small piece of planking on the top left corner as well as a small damaged area of planking on the top right corner that needed to be replaced (Figure 41 shows the replacement planking for the right side.). After each piece of replacement planking was cut to size it was screwed into place. These repairs required approximately 5 minutes per section to complete.



**Figure 41. Damaged Frame/Plank Above-Replacement in Place Below.**

Range 5 was not scheduled for firing on 4/29/2004 and therefore no training activities were affected. Materials used during the maintenance effort included sections of patching material (top rubber cover), the STAPP-supplied glue, rubbing alcohol, rags, and sandpaper for the patching and frame/plank sections

and associated screws for frame/plank replacement. The completed Maintenance Record for this effort is attached as **Appendix C-1**.

During this maintenance effort, BAHF Training Group instructed Fort A.P. Hill and NDCEE personnel how to properly perform maintenance to the Bullet Catcher. An *Operations and Maintenance Guide* provided by STAPP is available in **Appendix D**.

#### **5.4 Maintenance #3**

The third maintenance activity became necessary on 14 June 2004, forty-eight days since the previous maintenance activity. Fort A.P. Hill notified the NDCEE that some minor damage had occurred to the Range 5 Bullet Catcher frame and top rubber cover. Fort A.P. Hill conducted this maintenance without the aid of the NDCEE or BAHF Training Group personnel. The damage was limited to a few loose pieces of the frame/planking that needed to be re-tightened and secured (See Figures 42, 43, and 44). There was also a seam in the top rubber cover that had become loose and needed to be re-glued.



**Figure 42. Loose Plank on Right Side.**



**Figure 43. Loose Plank on Top.**



**Figure 44. Loose Plank on Left Side.**

Fort A.P. Hill did not have the proper supplies and materials on-site to perform the maintenance. Upon Fort A.P. Hill's request, BAHR Training Group delivered the required materials. The repairs made consisted of tightening 7 screws to re-secure the frame/planking and sanding, cleaning, and applying additional glue to the loose seam in the top rubber cover. The maintenance was performed by one person and required approximately eleven minutes to complete using the STAPP-supplied glue, rubbing alcohol, rags and sandpaper for the seam and screws for re-securing the frame/planking. The associated Maintenance Record is attached as **Appendix C-2**.

#### **5.5 Maintenance #4**

Fort A.P. Hill performed some minor maintenance to the Range 5 Bullet Catcher on 7 July 2004, twenty-four days since the previous maintenance activity. A small section of the frame/planking had become loose and needed to be tightened and resecured. The maintenance involved tightening five screws and required approximately two minutes to complete by a 1-man crew using a screwdriver and no additional materials. The completed Maintenance Record is attached as **Appendix C-3**.

#### **5.6 Maintenance #5**

On 30 July 2004, twenty-two days since the previous maintenance activity, Fort A.P. Hill repaired five slices in the top rubber cover of the Range 5 Bullet Catcher. The maintenance involved applying additional glue to seal the slices in the top rubber cover. Materials used were the STAPP-supplied glue, rubbing alcohol, rags, and sandpaper. Time to complete this maintenance activity was approximately ten minutes by a 1-man crew. The associated Maintenance Record is attached as **Appendix F**.

### **6.0 BULLET AND WATER REMOVAL AND DISPOSAL**

Clean Harbors Environmental Services of Prince George, VA was contracted to remove and dispose of the bullets from each Bullet Catcher as well as the water collected in the water collection reservoirs. This effort was performed in three days.





**Figure 45. Clean Harbors Environmental Services Inc.**

STAPP and BAHF Training Group constructed a scaled-down version of the STAPP-sifter for possible use during the bullet sifting effort. Mr. Moberg and Mr. Hargett demonstrated and explained the proper use of the STAPP-sifter to Clean Harbors and Fort A.P. Hill. The demonstration lasted approximately 1.5 hours. Both Clean Harbors and Fort A.P. Hill were impressed with the sifter and felt more than able to properly operate it. Clean Harbors reported that utilizing the STAPP-sifter was a better method of sifting and removing bullets from the granular rubber than using a mesh screen, their proposed method.

#### **6.1 Sifting and Removal of Bullets from Range 4**

The bullets that impacted the Bullet Catcher on Range 4 were confined to “hot spots.” In this instance a hot spot is an area with a high concentration of bullets/entry marks. Each lane had a hot spot approximately 70” (height) x 50” (width) located towards the lower section of the Bullet Catcher (Figure 46).



**Figure 46. Range 4, Lane 54 Hot Spot.**

At 9am on 18 August 2004 personnel from Fort A.P. Hill and the NDCEE met the Clean Harbors 4-man crew at Range 4. Clean Harbors began to remove the planking that secures the top rubber cover in order to begin the sifting process on Lanes 52, 53, and 54 of Range 4. Once the planks were removed and the top rubber cover pulled to the side, Clean Harbors immediately set-up their equipment and began to sift bullets from the granular rubber at approximately 10:40am.

The STAPP-sifter was used for this effort. The STAPP-sifter is a very simple design consisting of a table positioned at a defined slope with a small vibrator positioned on the underside of the table. The granular rubber and bullet mixture is placed onto the table and due to the vibrations slowly moves downward. At the end of the table is a piece of piping that is connected to a cyclone-vacuum and HEPA filter. The vacuum has enough suction to remove the granular rubber but not the bullets. The granular rubber is sucked via the cyclone and the air is filtered with a HEPA filter. The STAPP-sifter is shown being used in Figure 47.



**Figure 47. STAPP-Sifter in Use.**

As sifting of the hot spot continued, it became obvious that the majority of the bullets were located in the top 6-8 inches of the granular rubber. Once the entire hot spot was sifted and the bottom rubber liner exposed, the liner was visually inspected for tears/holes. There were no visible tears/holes in the bottom rubber liner (please see Figure 48). Lane 52 hot spot sifting was complete at roughly 2:55pm.



**Figure 48. Bottom Rubber Liner of Range 4, Lane 52.**

At approximately 3:15pm the sifting process began on Range 4, Lane 53. At roughly 5:10pm it began to rain and the top rubber cover had to be placed back over the granular rubber therefore halting all sifting operations.

At 7:00am on 19 August 2004, Clean Harbors' 3-man crew was on-site and immediately began to continue sifting Lane 53. As with Lane 52, the majority of the bullets were concentrated in the top 6-8 inches of the granular rubber. Once the entire hot spot was sifted and the bottom rubber liner exposed, the liner was visually inspected for tears/holes. There were no visible tears/holes in the bottom rubber liner (please see Figure 49). Lane 53 hot spot sifting was complete at roughly 10:40am.



**Figure 49. Bottom Rubber Liner of Range 4, Lane 53.**

After the granular rubber was removed, it was noticeable that there was some water accumulation in the Bullet Catcher. A puddle of water, roughly one-half gallon, was lying next to the water collection pipe at Lane 53 (See Figure 50). This was an indication that precipitation had entered the Bullet Catcher, which would be sampled, analyzed, and properly disposed of.



**Figure 50. Puddle of Water at Lane 53.**



At approximately 11:00am Lane 54 sifting operations began. As with the other lanes the hot spot area was 70 inches x 50 inches and the bullets were also contained in the top 6-8 inches of granular rubber. The bottom rubber liner was visually inspected. No holes/tears were found (see Figure 51). Lane 54 sifting was complete at 4:15pm.



**Figure 51. Bottom Rubber Liner of Range 4, Lane 54.**

The top rubber cover was pulled back into place and resecured with the appropriate planks. At approximately 5:20pm Range 4 sifting operations were complete.

The total weight of bullets removed from the Range 4 Bullet Catcher was 67 pounds.

## **6.2 Sifting and Removal of Bullets from Range 5**

At roughly 6:00am on 20 August 2004 Clean Harbors began the sifting process on Range 5. The hot spot on Range 5 was slightly larger than the hot spots on Range 4. The Range 5 hot spot was roughly 80 inches (length) x 55 inches (width) Figure 52 shows the hot spot with the top rubber cover pulled down and the granular rubber removed.



**Figure 52. Range 5 Hot Spot.**

Again, Clean Harbors chose to utilize the STAPP-sifter during the sifting process. Range 5 had bullets throughout the depth of the granular rubber. Once the granular rubber was removed from the hot spot, the bottom rubber liner was visually inspected. Upon inspections it was noted that there were roughly thirty holes/tears in the bottom rubber liner caused by bullets penetrating beyond the depth of the granular rubber. Some of the holes/tears had bullets protruding from them with several facing away from the bottom rubber liner. For more detail please see Figures 53, 54, and 55.



**Figures 53, 54 and 55. Holes/Tears (circled) in Bottom Rubber Liner of the Range 5 Bullet Catcher.**

The total weight of bullets removed from the Range 5 Bullet Catcher was 15 pounds.

### 6.3 Water Removal

Clean Harbors pumped all water from each Bullet Catcher water collection reservoir utilizing a wet/dry shop vacuum. In order to gain access to the water collection reservoir, a cap located on the lower right-hand corner of each Bullet Catcher had to be removed. These caps are covered by a few inches of granular rubber. Once the rubber was pushed aside and the caps removed, each reservoir was emptied.

Range 4 contained approximately eleven to twelve gallons of water, while Range 5 contained roughly six gallons of water. The water was sampled and taken for analysis by Clean Harbors. Clean Harbors provided a Toxicity Characteristic Leaching Procedure (TCLP) for all Resource Conservation and Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) on the sample. The test results are listed in Table 2.

**Table 2. TCLP Data**

| <b>Test Description</b> | <b>Final Result</b> | <b>EPA Limit</b> | <b>Units of Measure</b> | <b>EPA Test Method</b> | <b>Date Analyzed</b> |
|-------------------------|---------------------|------------------|-------------------------|------------------------|----------------------|
| <b>TCLP Metals</b>      |                     |                  |                         |                        |                      |
| Arsenic                 | <0.050              | 5.00             | mg/L                    | 3020/7060A             | 7 Sept. 04           |
| Selenium                | <0.050              | 1.00             | mg/L                    | 3020/7740              | 7 Sept. 04           |
| Silver                  | 1.08                | 5.00             | mg/L                    | 3020/7761              | 7 Sept. 04           |
| Barium                  | 0.212               | 100.00           | mg/L                    | 3020/7081              | 7 Sept. 04           |
| Cadmium                 | <0.010              | 1.00             | mg/L                    | 3020/7131A             | 7 Sept. 04           |
| Chromium                | <0.050              | 5.00             | mg/L                    | 3020/7191              | 7 Sept. 04           |
| <b>Lead</b>             | <b>7.58</b>         | <b>5.00</b>      | <b>mg/L</b>             | <b>3020/7421</b>       | <b>7 Sept. 04</b>    |
| Mercury                 | <0.002              | 0.20             | mg/L                    | 245.1                  | 7 Sept. 04           |

Note-All RCRA regulated metal concentrations in the water were below the EPA's regulatory limit with exception to lead. Due to the excessive lead content, the water must be disposed of as a hazardous waste.

## 7.0 COST ANALYSIS

### 7.1 Capital Investment

According to the vendor, start-up costs for the Bullet Catchers installed upon Range 4 and Range 5 at Fort A.P. Hill are as follows:

Materials---\$56,729 (\$47/ft<sup>2</sup>) This cost includes all labor, tools, and materials needed for ground preparation, complete installation, and training.

Shipping---\$5,400 This cost is for the shipment of all necessary materials from Sweden to Fort A.P. Hill, VA.

Total Cost---\$62,129

### 7.2 Operation and Maintenance

There was no daily operation costs involved with the use of either Bullet Catcher installed at Fort A.P. Hill. For the purpose of this demonstration/validation, a visual inspection performed after each firing session was conducted. These inspections required approximately 3-5 minutes to complete. The Range Control personnel who conducted these inspections had an hourly pay rate of \$12.50/hour. At this pay rate, each inspection cost \$0.63-\$1.04 to perform.

Maintenance costs were minimal. Only the time required to perform maintenance was considered for these costs since the range personnel were already on-site performing normal duties. Table 3 lists each maintenance activity and the associated costs, as described in Section 5.0.

**Table 3. Maintenance Activity Information**

| Maintenance Activity | Number of People | Time to Complete maintenance | Labor Cost at \$12.50/hour |
|----------------------|------------------|------------------------------|----------------------------|
|                      |                  |                              |                            |
| #1                   | 0                | 0                            | \$0.00                     |
| #2                   | 3                | Roughly 2 hours              | \$75.00                    |
| #3                   | 1                | 11 minutes                   | \$2.29                     |
| #4                   | 1                | 2 minutes                    | \$0.42                     |
| #5                   | 1                | 10 minutes                   | \$2.08                     |
|                      |                  | <b>TOTAL COST:</b>           | <b>\$79.79</b>             |
|                      |                  |                              |                            |



Materials required to perform the maintenance activities listed and the associated cost of materials were included in the purchase price of the Bullet Catchers. Per BAHF Training Group, the cost of materials necessary to perform all maintenance totaled \$874.00. In fact, none of the metal pins or mastic tape were used. The breakdown of maintenance materials is listed below:

- Top Rubber Cover material (\$25/ft<sup>2</sup>)-\$200.00 for 8ft<sup>2</sup>
- Plastic Frame/Planks (\$36/4"x1"x12' plank)-\$108.00 for 3 planks
- Metal Pins (\$12/Pin)-\$36.00 for 3 pins
- STAPP Glue (\$15/bottle)-\$60.00 for 4 bottles
- Mastic Tape (\$120/roll)-\$120.00 for one roll
- Total Material Cost-\$524.00
- Shipping cost from Sweden-\$350.00
- Total Cost-\$874.00

### **7.3 Disposal**

The costs associated with sifting bullets from the granular rubber and removing the water from the water collection system of each Bullet Catcher and their related disposal costs totaled approximately \$10,120. This \$10,120 expense included the labor, associated materials and tools, analysis of collected water as well as the complete disposal of all waste material removed from the Bullet Catchers (bullets and water). Waste materials included bullets and water, which were removed from the Bullet Catcher.

Currently there are no regulations that mandate remediation of an active firing range. But, for the sake of comparison, the total cost, as estimated by Clean Harbors Environmental Services, Inc., for remediation of the areas covered by the Bullet Catchers on both Range 4 and Range 5 is approximately \$221/ton or \$132,000, estimating 300 tons of soil to be remediated per range. This cost does not include adding soil or reseeding the berm. The breakdown of costs for remediation is as follows:

\$15/ton to excavate soil and load dump trailers  
\$125/ton for stabilization and disposal of material (assuming the material is hazardous for lead content)  
\$81/ton for transportation to final disposal site (Model City, New York)

If the tonnage of material for remediation were less than 300 tons, the cost would increase accordingly.

## **8.0 CONCLUSIONS**

Due to information previously listed in this report, one could assume that all on-target bullets fired upon the Bullet Catcher installed at Range 4 were stopped and contained

within the bullet trap itself and that no bullets/lead or lead contaminated water were introduced to the environment. Sifting efforts, hot spots only, showed that 67 pounds of bullets and the associated lead were contained within the Bullet Catcher.

On the contrary the same assumption cannot be made regarding the Bullet Catcher installed at Range 5, because of the documented damage to the bottom rubber liner. Although the depth of the granular rubber was not sufficient to properly decelerate .50 caliber rounds, which allowed those rounds to penetrate through the bottom rubber liner, the top rubber cover performed properly. The vendor originally stated that the Bullet Catcher technology would properly accommodate rounds up to and including 12mm. The .50 caliber round is slightly larger at 12.7mm. The vendor has since stated that with further research the depth of the granular rubber could be changed accordingly to properly accommodate .50 caliber rounds.

When compared to the use of a conventional soil berm, the use of a Bullet Catcher on Range 4 could drastically decrease the amount of lead introduced into the environment. Soil erosion and lead migration would also be reduced or possibly be eliminated.

Due to bullets penetrating the bottom rubber liner of the Range 5 Bullet Catcher, an accurate comparison to a conventional soil berm cannot be conducted. If the proper depth of granular rubber to adequately decelerate .50 caliber rounds could be determined, the same Bullet Catcher could also decrease or eliminate the amount of lead introduced to the environment on Range 5.

From the data collected during this demonstration/validation, it can be assumed that a Bullet Catcher installed upon a clean berm (or a lead contaminated but exempt from regulations berm) would have a cost savings in the event of a range closure requiring full remediation. When installed upon a clean, lead-free range, the amount of lead introduced to the environment would be minimal, if any, assuming all rounds are on target and impact the Bullet Catcher. In the instance when a Bullet Catcher is installed upon a lead-contaminated berm, the amount of lead introduced to the environment would be limited to the amount of lead present at the time of installation (Again, assuming that all rounds are on target and impact the Bullet Catcher.).

Due to bottom rubber liner damage associated with Range 5, the STAPP Bullet Catcher can be recommended for an alternative to conventional soil berms for use at small arms ranges firing 5.56mm and 9mm rounds, including tracer rounds.

## **Appendix A.**

### **Demonstration/Validation Plan**



"0049-04 Final  
DemVal Rev2 1-21-0

## **Appendix B.**

### **Range 4 Data Information**



"Range 4 Data.xls"

## **Appendix C.**

### **Range 5 Data Information**



"Range 5 Data.xls"

**Appendix D.**  
**Maintenance Activity Sheets**

**Maintenance Activity:** Range 5  
\*\*\*Patch top rubber cover and repair/replace planking.

---

**Date:** 29-Apr-04

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**Start/Completion Time:** 8:45am-10:45am

---

| Name of Person(s)<br>Involved | Title and<br>Contact Information          | Time devoted to activity<br>(Total Hours)    | Work Performed<br>(Description of Steps Involved)                         | Materials   |
|-------------------------------|---|--|---|---|
| John Speare                   | Data Collection/<br>Maintenance personnel | 2 hours                                      | Cut patches to size, sand, clean, glue<br>damaged areas, replace planking | top rubber cover<br>material, sand paper,<br>rags, rubbing alcohol, |
| Mike Hargett                  | BAHR Training Group                       | 2 hours                                      | Cut patches to size, sand, clean, glue<br>damaged areas, replace planking | glue, planks, screws  |
| Bart Bartholomew              | BAHR Training Group                       | 2 hours                                      | Cut patches to size, sand, clean, glue<br>damaged areas, replace planking |   |
| Gino Spinos                   | NDCEE                                     | 2 hours, mostly observing<br>and documenting |   |   |
|                               |   |  |   |   |



**Maintenance Activity:** Range 5  
\*\*\*Tighten and secure screws holding in place planks on the left and right sides.  
\*\*\*Re-glue slices on the top portion of the top rubber cover (4 slices).

**Date:** 24-Jun-04

**Start/Completion Time:** 11-11:10 A.M.

| <b>Name of Person(s)<br/>Involved</b> | <b>Title and<br/>Contact Information</b>  | <b>Time devoted to activity<br/>(Total Hours)</b> | <b>Work Performed<br/>(Description of Steps Involved)</b> | <b>Materials</b>                     |
|---------------------------------------|---|---|---|--------------------------------------|
| John Speare                           | Data Collection/<br>Maintenance personnel | 2-3 minutes                                       | Tighten screws (7)  | None                                 |
| John Speare                           | Data Collection/<br>Maintenance personnel | 7-8 minutes                                       | Re-glue sliced areas (4)                                  | Glue, alcohol,<br>rags,<br>sandpaper |
|                                       |   |   |   |                                      |
|                                       |   |   |   |                                      |

**Maintenance Activity:** Range 5  
\*\*\*Tighten and secure screws holding in place planks.

**Date:** 30-Jul-04

**Start/Completion Time:** 12:30pm-12:40pm

| Name of Person(s)<br>Involved | Title and<br>Contact Information          | Time devoted to activity<br>(Total Hours) | Work Performed<br>(Description of Steps Involved) | Materials                          |
|-------------------------------|---|---|---|------------------------------------|
| John Speare                   | Data Collection/<br>Maintenance personnel | 10 minutes                                | Re-glue sliced areas (5)                          | Glue, rags, alcohol,<br>sand paper |
|                               |   |   |   |                                    |
|                               |   |   |   |                                    |
|                               |   |   |   |                                    |

**Appendix E.**

**Operations and Maintenance Manual  
STAPP Bullet Catcher**



## **OPERATIONS AND** **MAINTENANCE GUIDE**

# **STAPP Bullet Catcher**

### **User Restrictions**

The Stapp Bullet Catcher is specifically designed for military firearms with full metal jacket ammunition of calibers: 5.56; 7.62; 9.0 mm.

Small arms rounds up to 12,0 mm can be used.

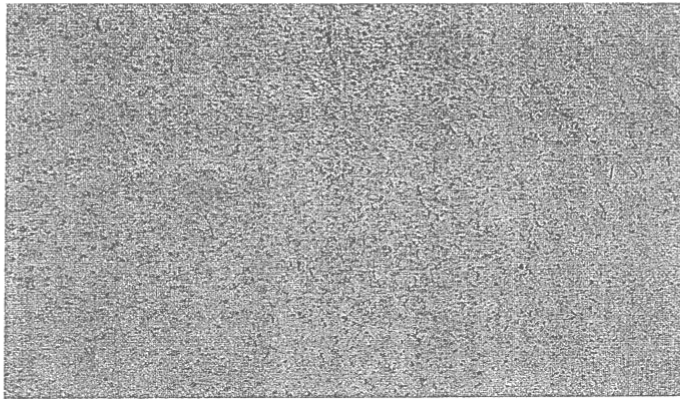
Tracer ammunition can be used when there are no openings in the protective rubber cover cloth and at seams joining the bottom cloth.

**Note:**

- 1) Other ammunition than that prescribed above can be used but could require that the Bullet Catcher have additional cleaning and maintenance scheduled.
- 2) Ammunition with low impact energy should not be used on the Bullet Catcher. (It may cause ricochets or get caught in the cover cloth.)

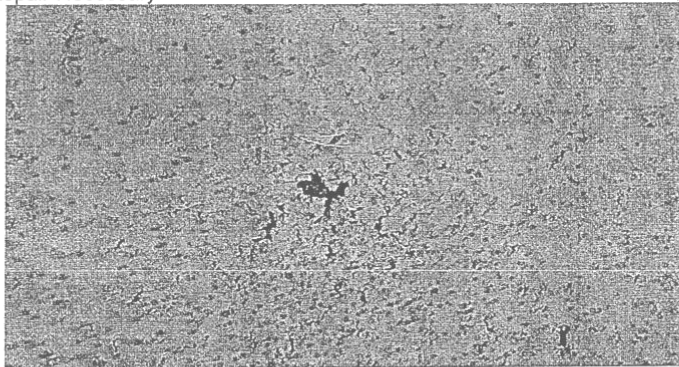


## ANALYSIS: COVER CLOTH WEAR

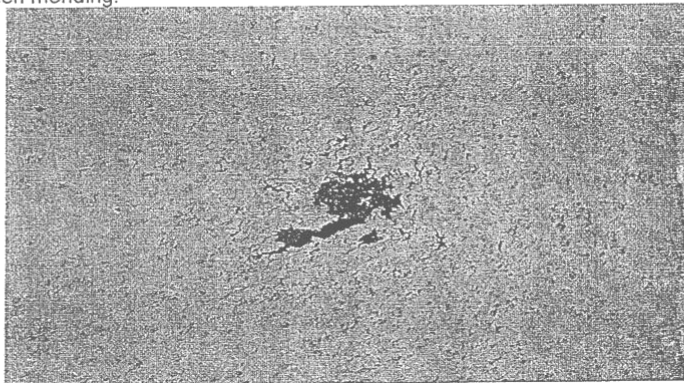


Repair Necessary

Riko-Rub 6,0 mm.



Damage is insignificant and local. Repair may soon be needed to prevent penetration of bullets up- and water down- through opening(s), and to protect against ricochets. CA-glue is recommended when mending.



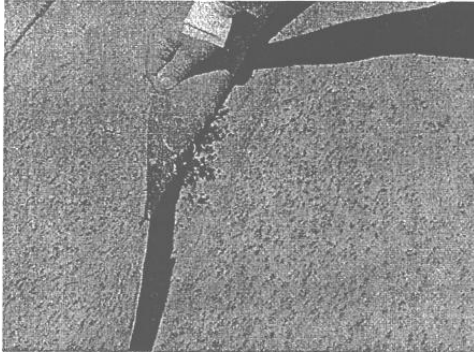
Bullet Catcher is saturated after intensive shooting with low-energy impact, large-bore rounds. Repair is imminent. It is recommended that upper rubber granules be replaced with new. Mend using CA-glue (alternative 1) or vulcanized-tape, (alternative 2).



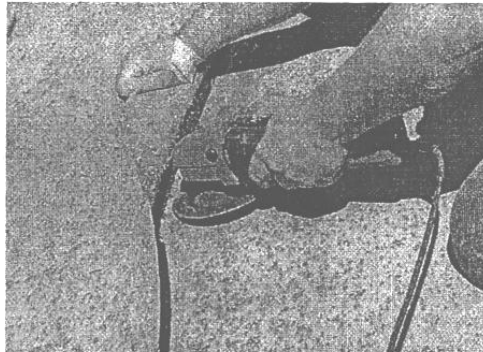
## Operations & Maintenance Guide

### Alternative 1

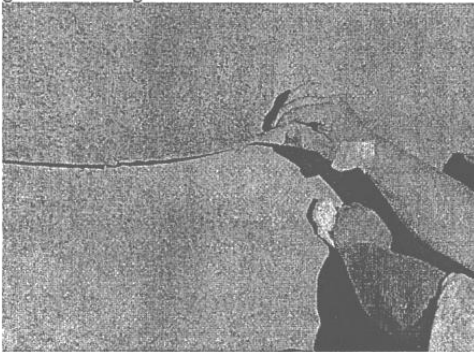
The pictures below give step-by-step instructions on repairing an open seam using glue. (Please read the directions for use and safety in the glue manuals.)



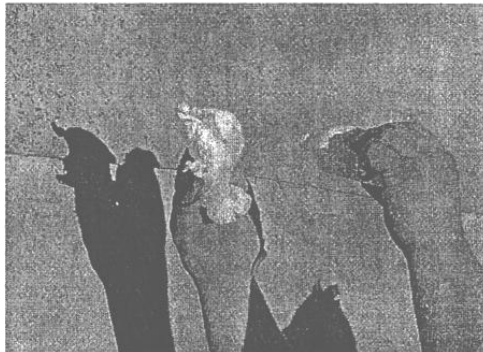
1. Open carefully and remove the rubber granules caught in the seam.



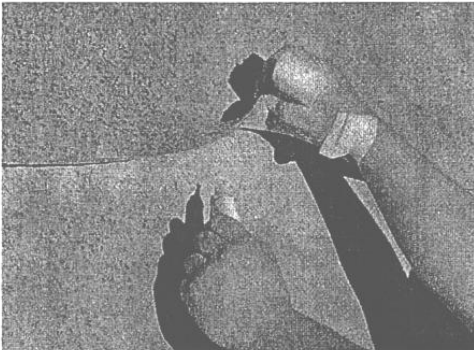
2. Sand the seam parts with abrasive paper no. 80



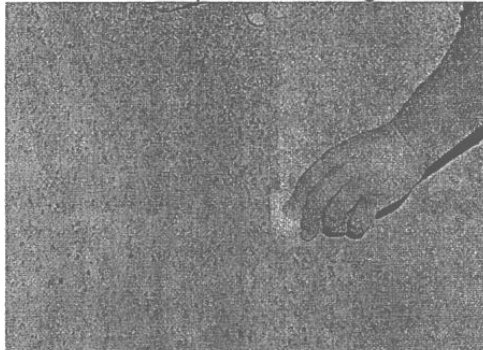
3. Take away the grinding dust with a dry rag.



4. Clean the seam parts with ~~sheer gasoline~~ methyl alcohol



5. Carefully apply CA-1500 glue in three to four strings (rows) spaced for full width of seam.



6. Dab extra glue using a handy *pad* in seam and edge, joining them together.

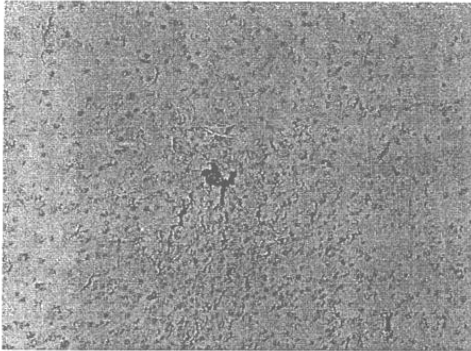
The glue is made of *cyanogeneacrylate*. Breathing protection is (only) necessary when working with large repairs and for extended periods. Protective gloves must be made from polyethylene to avoid glue sticking to gloves.



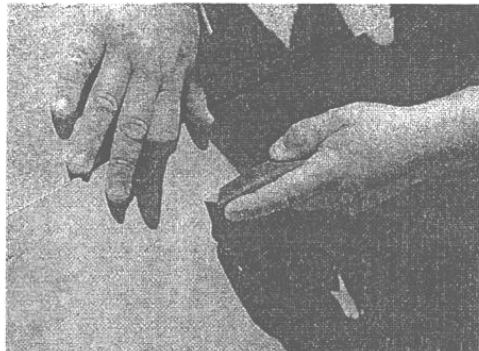


### Alternative 2

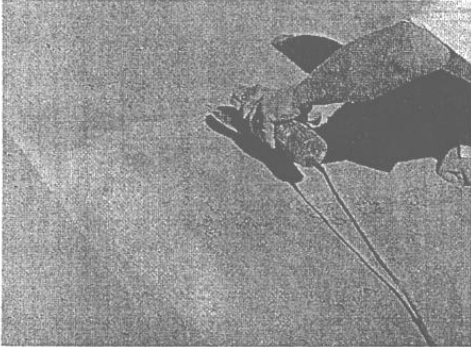
The pictures below illustrate a repair technique using rubber patches with cold vulcanized rubber tape.



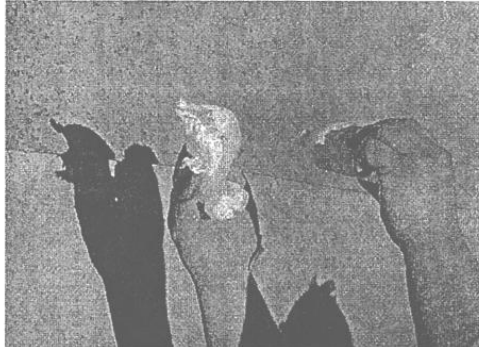
1. Example of wear damage which should be covered with a repair patch.



2. Using a razor knife, cut a rubber patch 200mm larger than the surface to be covered.



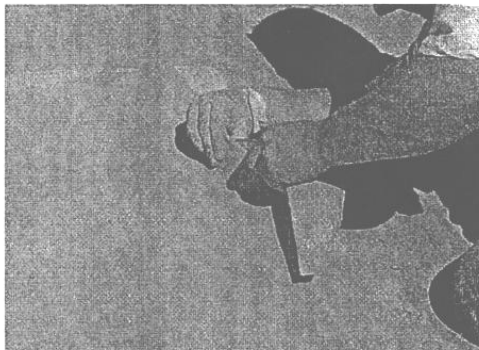
3. Sand as instructed in Alternative 1. Dry dust away with a rag.



4. Clean the seam areas with ~~sheer gasoline~~ methyl Alcohol



5. Apply rubber tape of 2-1/4"/60mm width around the rubber patch.



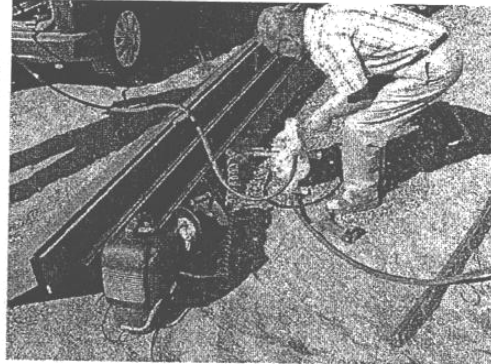
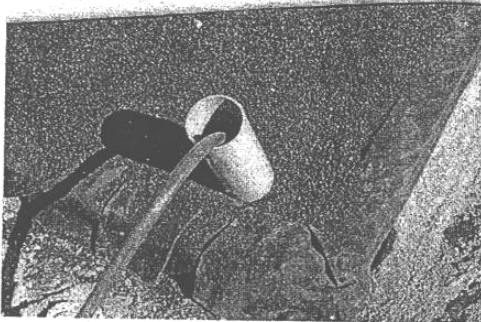
6. Remove safety paper to attach the rubber patch to the area to be repaired. Press firmly.

The repair process is basically the same as in **Alternative 1**, but methyl alcohol can be used in place of gasoline. The tape should be at least +F68° before applying.



## Operations & Maintenance Guide

Analysis of accumulated water held in collection pipe.



1. A fixed board is gently loosened at the corner where the mark for sleeve coupling (sc) is placed.
2. Fold cloth up in the corner and weight.
3. The lid of the sc is located below in the rubber particulate. A pipe with diameter= 5-1/2"/150mm is secured over the sc.
4. Remove rubber granules so that the lid can be unscrewed without having rubber granules fall down into the pipe opening.
5. Place hose of the pump into the sc and pump water into a sampling bottle.
6. Vice versa procedure when montage.
1. The pump equipment contains a self suction membrane pump.
2. The pump operates with compressed air from a compressor.
3. Pumping is performed in two rounds taking sample bottle first for analysis.
4. Analysis of the accumulated water will indicate the extent of settled contamination and treatment required.
5. Pump all remaining water for disposal.
6. Empty accumulated water two years after installation and then in intervals indicated after analysis.
7. The interval can also be decided with a leveler driven by 9-voltage batteries.

Stapp AB provides complete service. Analysis conducted by accredited laboratory. Analysis results are issued to customers with recommendations for further considerations and repair.

Stapp AB provides full service including repair, maintenance and support. Stapp AB also provides services for cleaning the rubber granules and proper handling of projectiles and *accumulated* water

Stapp AB provides spare parts and repair materials.

Stapp reserves the right to change the above information at anytime.

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## **Appendix F.**

### **Maintenance Activity Form**



"Maintenance #4  
Form 7-30-04.xls"